

Application No.: 10/696,349
Docket No.: PE0649 US DIV2

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REMARKS

The above amendments and the below remarks are responsive to the Office Action, dated December 19, 2005, and are submitted in support of Applicants' request for continued examination in the above referenced pending application.

The specification has been amended as requested in the last Office Action.

Claim 20 has been amended to correct errors that had been left uncorrected by the last amendment. New Claim 22 has been added, which finds support at page 7, line 8 of the application. No new matter has been introduced by these amendments.

The pending claims are 12-22.

Rejections under 35 U.S.C. § 103

1. WO 01/41512 and Polymer Preprints 41(1), 2000, pp. 770-771

Claims 13-15 and 17-21 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over WO 01/41512 ("Thompson") in view of the article by Djurovich et al., Polymer Preprints 41(1), 2000, pp. 770-771 ("Djurovich"). Applicants respectfully traverse this rejection

Claims 13-15 and 17 (compound claims) and 18-21 (device claims)

Applicants' claims 13-15 are compound claims and conform to the general formula L_3M where each L is the same bidentate ligand. In each of these claims, the phenyl (or aryl) ring is substituted with two fluorine atoms (claims 14 and 15) or three fluorine atoms (claim 13). Device claims 18-20 comprise a layer that comprises at least one compound of claims 12-17. Claim 21 is drawn to an organic electronic device comprising an emitting layer comprising at least one compound having the formula $IrL^aL^bL^c$ wherein each of L^a , L^b and L^c are alike or different and have structure XI or XII. Structure XI is a phenylquinoline and Structure XII is a phenylisoquinoline. *Thompson* discloses organometallic compounds of formula L_2MX where L and X are distinct bidentate ligands (page 1, lines 8-9). *Thompson* also discloses organometallic compounds of formula $LL'L''M$ wherein each of L , L' and L'' are distinct bidentate ligands (page 3, lines 26-27) or are the same or different (page 3, line 35). *Thompson*'s Fig. 39 discloses an arylisoquinoline labeled as "arylquinolines" but does not disclose an arylisoquinoline. From this it can readily be seen that claims 13-15 and 18-20, being directed to L_3M compounds, are distinct from L_2MX and $LL'L''M$ where each of L , L' and L'' is a distinct bidentate ligand. Formula XI is also distinct from anything disclosed in *Thompson*. Fig. 39 in *Thompson* is the only depiction in the entire

disclosure of the basic structure labeled "arylquinoline" and is shown with one substituent, R', R" and R"', respectively, on each ring of the system. These substituent groups are nowhere defined. R groups are conventionally understood to represent alkyl groups, and may include phenyl or aryl groups if so defined. X conventionally represents halogen. The only depiction of arylquinolines in *Thompson* therefore teaches that all three rings are substituted once each with alkyl or possibly phenyl or aryl groups.

Thompson's preferred embodiment is clearly L₂MX (page 12, lines 23-28 and claims 1-13, 15, 20 and 22), and pyridines, pyridyls, and indole are the preferred L constituents, benzoquinoline as well, with acac the preferred X. See generally Examples (page 17, lines 24-25, page 18, lines 26-31, page 19, lines 1-16 and 23-31, page 20, entire, page 21, lines 1-12, Figs. 39 and 40 by way of example). *Djurovich* is directed exclusively to phenylpyridines (ppy) and enhanced solubility of fluorinated ppy. None of Applicants' ligands comprise ppy, and therefore it would not have been obvious to one skilled in the art to combine *Djurovich* with *Thompson* to arrive at the Applicants' ligands or the general formula L₃M, Structures XI and XII, or the specific compounds disclosed in claims 12-17. *Djurovich* teaches only one compound, an iridium complex having three ppy ligands, substituted with fluorine ("FIppy"). The Examiner further stated that it would have been obvious to use the fluorine of FIppy as the substituents on the "arylquinoline" ligand of *Thompson* in order to improve the solubility. Applicants respectfully disagree with this assessment. The ligand of the *Djurovich* complex is a phenylpyridine, not a phenylquinoline or phenylisoquinoline. While *Djurovich* may disclose empirical evidence that fluorinating the ppy disclosed therein rendered it more soluble while reducing emission efficiency only slightly, this does not teach or suggest that fluorinating any other emissive species would have the same conjunction of useful and beneficial results. It is respectfully submitted that one of ordinary skill reading *Djurovich* would not have been led to choose fluorine as a substituent on a phenylisoquinoline ligand with the expectation of achieving identical results.

Claim 21 is directed to a device in which three ligands, which may be alike or different, selected from Structures XI and XII, are bound to a metal. As noted previously, Structure XI is phenylquinoline, while Structure XII is phenylisoquinoline. The substituents are, generally, fluorine, fluoroalkyl, fluoroalkoxy, and difluoromethoxy or difluorohalomethoxy. As noted above, *Thompson* does not disclose a phenylquinoline such as XI and the arylquinoline of Fig. 39 is limited to one substituent group per ring, where there is no teaching or suggestion that the substituents are equivalent to those recited in claim 21.

The Examiner stated that it would have been obvious to use greater than 20% by weight of the iridium complex in the light-emitting layer of *Thompson* in order to increase the total amount of light emitted. Applicants respectfully disagree with this conclusion. *Thompson* does not teach a range of concentrations for an iridium complex in a light-emitting layer. *Thompson* discloses one data point: a device in which the light-emitting layer L₂MX is 12% by weight bis(2-phenylbenzothiazole)iridium acetylacetone ("BTIr") in 4,4'-N,N'-dicarbazole-biphenyl host material (page 13, lines 9-16, page 30, lines 4-8, and claim 7). This light-emitting layer when present at 12% by mass has a quantum efficiency of 12%. The BTIr complex does not have a ligand with Applicants' structure (XI) or (XII). *Djurovich* teaches that devices with maximum efficiency are obtained with FIrppy concentrations in the range of 2 – 3.5 wt%. (see last paragraph on page 771). Again, the FIrppy complex does not have a ligand with Applicants' structure (XI) or (XII) as recited in Claim 21, nor does it have the ligand of the BTIr complex of *Thompson*. The *Thompson* and *Djurovich* references taken individually or collectively do not teach any concentration range for iridium complexes having a ligand with Applicants' Claims 13-15 or structure (XI) or (XII), as recited in Claim 21. *Djurovich*'s Fig. 3, page 771, shows quantum efficiency vs current density for FIrppy in a single-layer LED with poly(N-vinylcarbazole) host material, where four different concentrations of FIrppy are plotted. *Djurovich* teaches that for the specific composition disclosed quantum efficiencies are greatest at emitter concentrations of 2.2% and 3.5% by weight and at current densities of 40 mAcm⁻² or less. *Djurovich* significantly teaches that "[t]o our knowledge" the quantum efficiency of 1.7% reached at 2 – 3.5 % weight concentrations of FIrppy "is the best achieved" for a single-layer LED based on the particular host material and dopant therein disclosed. *Thompson* teaches only that 12% by weight BTIr dopant in CBP host (page 13, lines 9-16) has a quantum efficiency of 12%, with no disclosure or suggestion as to how the quantum efficiency might be increased or otherwise modulated by other variables, such as current density, host material, ligand identity, and combinations of the same or different ligands, and so forth. *Thompson*'s emitter compound is based on the formula L₂MX wherein L = 2-phenylbenzothiazole and X = acetylacetone, ligands not present in the claims under review.

Accordingly, Applicants respectfully assert that the reliance on *In re Woodruff*, 16 USPQ2d 1935, 1937 (CAFC 1990) and *In re Huang*, 40 USPQ2d 1685, 1688 (CAFC 1996), is misplaced, based as it appears to be on the assumption that the concentration of the Ir metal complex alone is a result effective variable. Combining *Djurovich* with *Thompson* teaches that for any emitter complex – host combination,

quantum efficiency must be empirically determined and cannot be presumed from the data presented in the prior art. The prior art teaches against any such determinations.

2. WO 01/41512; *Inorganic Chemistry*, Vol. 30, 1991, 1685-1687; and
WO 00/70655
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Claims 12-21 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Thompson* in view of the *Dedeian* et al. article *Inorganic Chemistry*, Vol. 30, 1991, 1685-1687 ("*Dedeian*") and WO 00/70655 ("*Baldo*"). Applicants respectfully traverse this rejection.

Claims 12-17

Applicants' remarks pertaining to *Thompson* presented above are equally applicable here, and are reasserted without being rescripted in this space. As noted above, *Thompson* does not teach or suggest compounds having the specific phenylisoquinoline ligands recited in Applicants' Claims 12-17. *Thompson* indicates the possibility of substituents on the aromatic rings of the "arylquinoline" ligand in Figure 39. However, there is no explicit teaching as to what these substituents could or should be, other than identifying them as R groups, which are commonly understood to represent alkyl and possibly phenyl and aryl groups. *Thompson* teaches in the paragraph bridging pages 34 and 35, that in L₂MX complexes, the X ligand can, in some cases, affect the energy of emission and efficiency. There is no suggestion that the L ligands themselves, and/or substituents on the L ligands can be used to tune the color. There is no teaching at all of substituents on the R groups for the arylquinoline structure shown in Fig. 39.

Dedeian discloses several monosubstituted and unsubstituted phenylpyridine ligands (Table I) in an article devoted to the disclosure of a new synthetic route to the preparation of Ir(III) complexes with 2-phenylpyridines. The Examiner has pointed to *Dedeian* as a reference combinable with *Thompson* to provide fluorinated [Ir(4-F-ppy)₃] and trifluoromethyl [Ir(4-F₃C-ppy)₃] substituents for the complexes of *Thompson*. *Dedeian* identifies *fac* tris-ortho-metallated Ir(III) complexes as strong photoreductants. There is no teaching or suggestion in *Dedeian* that any complex therein disclosed would be useful as a phosphorescing molecule. The Examiner has pointed out that the *Thompson* and *Dedeian* references share a common author. The intended import of this is not understood. Since *Thompson*'s priority date (1999) occurred years after the publication of *Dedeian* (1991), the *Thompson* inventors were generally aware, through the common author P.I. Djurovich, of fluorine and

trifluoromethyl as ligand substituents, it is to be expected that they would have claimed such substituents if they were suitable for the phenylisoquinoline ligands of *Thompson*. The failure to list fluorine, fluoroalkyl or trifluoromethyl as a substituent is, if anything, an indication teaching against their use. To the extent that F and CF₃ were known ligand substituents, they were known with respect to phenylpyridine, and other than the data in Table I of *Dedeian*, there is no teaching as to the effects these ligand substituents, their placement, or variations on them, would have on color, intensity, durability, and other properties. All of the *Dedeian* Ir(ppy)₃ species shown that have substituents are substituted in the 4-position except for one, methoxypyridine, which is 5-substituted. For this reason, Applicants respectfully traverse the statement that *Dedeian* shows that the substituents can be placed anywhere on the ligand. It is not clear from a reading and careful examination of *Dedeian* whether the substituents were placed where they were to demonstrate that such variations would not affect the desired *fac* product of the synthesis rather than having anything to do with phosphorescent properties. As noted earlier, the principle theme of this article is to describe a new synthetic pathway to Ir(ppy)₃ complexes.

Dedeian also, in fact, teaches that the different substituents have little effect on the chromophoric properties of the complexes: "The similarities in the lifetimes and emission energies of all the *fac*-Ir(R-ppy)₃ complexes indicate that they, like Ir(ppy)₃, each emit from an MLCT excited state." Page 1687, Col. 1, first full paragraph. The same text goes on to indicate that the relative ease of oxidation of Ir(III) to Ir(IV) is seen where electron-donating substituents are borne on the ligands rather than electron-withdrawing groups. While this teaching is generally useful in promoting transfer of an electron from the metal to a ligand, it does not teach anything about phosphorescent properties or how to modulate for color, intensity, durability, and so on. *Dedeian* also discloses λ_{em} values (Table I) which are all outside the range set forth in Claim 21. There is no suggestion in either *Thompson* or *Dedeian* that substituting a F atom or a CF₃ group on a ligand of completely different chemical structure from ppy would certainly, or very likely, have phosphorescent effects and give rise to the ability to modulate properties.

Baldo is directed to Ir(ppy)₃ complexes which may be substituted with alkyl or aryl or may be modified by altering the atoms of the aromatic structure. Page 14, lines 11-20. No substituted ligands are exemplified. The teaching of *Baldo* on pages 14 and 15, refers to the different properties of tris complexes with different ligands, i.e., phenylpyridine, phenylpyrimidine, and bipyridine ligands. There is no suggestion of other ligands, and certainly no suggestion of other substituted ligands. *Baldo* teaches that the ligands should be placed on the 3, 4, 7 and/or 8 positions on the ligand "for

steric reasons" and limits his teaching on substituents to the conditional statement that different substituents "should give different color emission and may have different carrier transport rates." [Emphasis added] Based on the combined teachings of *Thompson*, *Dedeian*, and *Baldo*, and absent Applicants' discoveries, one of ordinary skill in the art would not know to use fluoro or trifluoromethyl substituents on a phenylisoquinoline ligand and arrive at the compounds recited in Claims 12-17.

Applicants respectfully request that the rejection be withdrawn with respect to Claims 12-17.

Claims 18-20

With respect to Claims 18-20, Applicants respectfully submit that electronic devices comprising the compounds of Claims 12-17 are not taught or suggested by *Thompson*, *Dedeian*, and *Baldo*, for all the reasons enumerated above.

Applicants respectfully request that the rejection be withdrawn with respect to Claims 18-20.

Claim 21

As stated above, *Thompson* does not teach a range of concentrations for an iridium complex in a light-emitting layer. As presented above, any relationship between the concentration of dopant and quantum efficiency depends upon the identity of the dopant and that of the host. Reading *Thompson*, *Dedeian* and *Baldo* together teaches this, and *Thompson* and *Baldo* have already been discussed and analyzed in this regard. *Baldo*'s Fig. 2 plots quantum efficiency vs current density and clearly shows that there is no direct relationship whatsoever between dopant concentration and quantum efficiency. *Baldo* shows varying concentrations of Ir(ppy)₃ dopant with CBP host material, BCP host material, and without host material. The highest quantum efficiencies are shown by the dopant with CBP host (6% dopant concentration has the highest efficiency followed by 1% followed by 12%). The next highest quantum efficiency is shown by the dopant in 100% concentration (with no host material). The lowest quantum efficiency is shown by 6% dopant in Alq₃ with BCP.

Thompson's BTIr complex does not have a ligand with Applicants' structure (XI) or (XII) as recited in Claim 21 and new Claim 22. *Dedeian* relates to the use of the iridium complexes as photoreducing agents and does not discuss electronic devices at all. *Baldo* teaches in Figure 2 that with iridium complexes having three phenylpyridine ligands, the efficiency of devices drops dramatically when the emitting layer in CBP host material has more than 6 wt% Ir(ppy)₃. The *Thompson*, *Dedeian*, and *Baldo* references taken individually or collectively do not teach any concentration

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range for iridium complexes having a ligand with Applicants' structure (XI) or (XII), as recited in Claim 21.

There is no suggestion in these references that combining them would lead to the Applicants' compounds and devices. Any such suggestion is conspicuously absent, given common authorship/inventorship by P.I. Djurovich in *Thompson* and the common inventors between *Thompson* and *Baldo*: M.E. Thompson, S. Lamansky, S.R. Forrest, M.E. Baldo, and P.E. Burrows. *Dedeian* was published about eight years before *Thompson* and *Baldo* were filed, so that the inventors had F and CF₃ as well as OCH₃, available as ppy ligand substituents but chose not to disclose or claim them in their later patent applications on either ppy or "arylquinoline". This choice on their part can be taken circumstantially to teach away from the use of such substituents on phenylisoquinoline and phenylquinoline ligands.

Applicants respectfully request that this rejection be withdrawn with respect to Claim 21.

Conclusion

In view of the foregoing remarks, Applicants respectfully submit that the above referenced pending application is in condition for allowance. A Notice of Allowance for Claims 12-22 is therefore earnestly solicited.

Respectfully submitted,


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